Cyber-Therapy: The Use of Artificial Intelligence in Psychological Practice

Chapter · January 2021

DOI: 10.1007/978-3-030-68017-6_19

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Cyber-Therapy: The Use of Artificial Intelligence in Psychological Practice

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Abstract. Cyber Therapy is a research project based on the relationship between Computer Science and Psychology. We are working on post-traumatic stress disorder (PTSD) due to severe traffic accidents using a virtual reality driving simulator and ECG, EDA and breathing sensors. With the help of virtual reality (VR) our goal is to build one software that can process the user's biofeedback signals - heart rate, body temperature, state of tension, etc. - in real time, to make the phobic stimulus autonomous. To this purpose, we developed a platform capable of adapting the phobic stimulus based on the user's biofeedback signals. We believe that this human-computer integrated system could be useful to patients as it would allow them to face fear autonomously, and to the psychotherapist, as it would allow a real time - physiologically based - knowledge of fear symptoms severity able to promote a timely and more appropriate program of intervention.

Keywords: Virtual reality · Psychology · PTSD · Cyber therapy

1 Introduction

Cyber therapy can be defined as the use of innovative technologies that help traditional therapy in the clinical field of psychology [1]. Its effectiveness is mainly due to its imaginative power, which allows patients to experience real situations; as well as the possibility of actively perceiving one's own body within a simulated environment (i.e., Virtual reality - VR - based); and its connectivity [1]. VR allows the subject to feel immersed in a temporally and spatially different place, thanks to the technological setup capable of processing the visual-sound information and returning it to the subject in real time. Within immersive VR, mediated by the use of a 3D helmet, it is possible to experience feelings of telepresence [2], which is due to the possibility of making real movements in a virtual environment. For these reasons, bringing a person into a stressful virtual situation causes increased heart rate, increased skin conductance, and other body responses like the real-world situation [3]. Recent studies show that cyber

Russo et al. (Eds.): IHSI 2021, AISC 1322, pp. 1–6, 2021.
https://doi.org/10.1007/978-3-030-68017-6_19

therapy allows the patient to obtain better results than traditional therapy [4, 5]. It is used to treat anxiety or specific phobias [6] such as fear of public speaking [7] arachnophobia [8, 9] and PTSD [10, 11]. For example, in arachnophobia Hofmann et al. [8] show that VR treatment, associated with increased touch (the ability to touch a silicon spider in the real world, while the patient sees a real spider in the virtual world) reduced the fear after only three sessions (N = 36. 8 subjects with clinical phobia). In a recent study, Rothbaum et al. [12] showed a reduction in phobia in 9 Vietnam veterans with PTSD in response to Cyber therapy; Moreover, Wald [13] showed a 60% reduction in phobia severity on 5 subjects with driving phobias; similarly, Beck et al. [11] reported that 10 treatment sessions with VR reduced symptoms severity c in 6 patients affected by PTSD due to a car accident.

Overall, the use of VR technology in the clinical setting is a valid support for memory or imagination helping the user to face the feared situation. In PTSD mental images i.e. flashbacks, intrusive images, memories [14] play an important influence in the amplification of emotions [15]. VR can be used as a useful imaginal system to induce positive responses [16] that allow the user to face the fear.

Based on this idea, we aim to build up a virtual environment where the exposure to fear related scenario is dynamically calibrated to the level of tolerance of the patients, established from the analysis of their psychophysiological response. This tool can be used by psychologists to create an Avoidance Hierarchy of stressful situations [17] based on the analysis of psychophysiological signals, which can be automatically used to establish the exposure to progressively stressful (i.e., anxiety generator) scenarios, as the level of tolerance to the previous one increases. In alternative, the psychologist can determine the Avoidance Hierarchy in a traditional way and define in the system the anxiety level for the patient, who can then be exposed progressively to the intervention, based on the severity level suggested by the psychologist and on the user's reaction to the phobic stimuli.

2 Our Research

2.1 Instrumental

In our experimental setup we use a virtual reality driving simulator (based on the VR headset "Oculus Rift"), equipped with rotation and position sensors and integrated headphones, that provide a 3D audio effect. The driving simulator is composed of a steering wheel with force feedback and pedals (Logitech G27), combined around a real car seat, used to provide a full driving experience during the simulation.

Moreover, we use the BioSignalsPlux Kit, and specifically the ECG, Respiration and EDA sensors – Fig. 1-, whose data are recorded using Python 3.7 program and post-processed using the Neurokit library. Unity 3D 18.4.22 was used to build highly immersive and realistic virtual scenarios (based on Windridge City for AirSim assets).

Fig. 1. BioSignalsPlux Kit. On the left EDA sensor; on the right ECG and respiration sensors

We use ECG, EDA and respiration data because the electrocardiogram allows us to measure the electrical activity of the heart using electrodes placed on the skin, which enables the detection of small electrical changes during each cardiac cycle; while electrodermal activity (EDA) records attentional, affective and motivational processes through bodily responses. In particular, the skin conductance level (SCL) and the respiration rate are reliable measures of the degree of stress [18].

2.2 Procedure

In our study we want to test a sample of 200 subjects, divided into two subgroups, each consisting of 100 subjects. The first group has a PTSD condition, due to a road accident, whereas the second group is made of 100 healthy subjects (control group).

Subjects will be asked to complete a 30-min VR driving session, in which they will be involved in situations of unavoidable road accidents. The subject's biological signals are continuously recorded during the driving session.

Currently, for our prototype, we have outlined 15 scenarios of stressful driving situations, divided into 3 groups:

1. Soft group: driving in adverse weather and/or heavy traffic conditions - Fig. 2A;
2. Mid-Hard group: driving while an accident occurs that does not involve the driver – Fig. 2B;
3. Difficult group: driving into an accident that involves the driver – Fig. 2C.

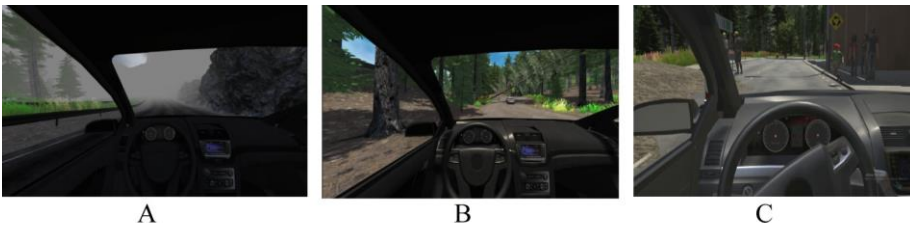

Fig. 2. A: Level easy. Driving with the fog; B: Level medium. Driving with accidents that do not involve the driver and C: Level Hard. Driving with an accident involving the driver

Generally, VR sessions proceed through gradual exposure, in order to respect the patient's personal rhythm [19]. Our scenarios will be combined creating an order of increasing difficulty (easy-medium-hard), but the order of execution of the scenarios can be changed according to the patient's anxiety state. This allows us to re-propose less stressful scenarios as soon as the patient's vital signs are above average.

Furthermore, the order of presentation of the scenarios can be customized on the basis of the prior traumatic experience of the subject. For this aim, we ask the psychologist to adjust, according to the patient experience, each scenario as easy, medium or difficult before entering the virtual world, following a similar approach to the Avoidance Hierarchy [17].

2.3 Implementation

The system works through continuous communication between its constituent parts, namely a Python application, collecting and analyzing the ECG, EDA and respiration rate from the BioSignalsPlux kit, and the Unity 3D application running the simulated environment. At the beginning of the experimentation, the system calculates the baseline of the 3 biosignals over 60 s. After baseline calibration, the vital sign acquisition application continuously reads the subjects' values and reports them to Unity every 10 s, using windows of 30 s and compares them to the baseline values. When the difference between the current value and the baseline is higher than a predetermined threshold, the status of the user is set to stressed, otherwise it is set to relaxed. These values were established empirically, based on the analysis of an existing dataset of biosignals acquired in VR. If the user is relaxed, the simulation environment proposes phobic stimuli with an increasing level of difficulty, otherwise it keeps proposing stimuli that are on the same level.

2.4 Single-Case

So far, we have performed tests on only one person from the non-clinical population.

The user was subjected to 3 scenarios belonging to 2 different levels (easy and medium). Specifically, the simulation began with driving in adverse weather conditions (dense fog) and continued with road accident conditions without the involvement of the user (side impact between two vehicles, falling of a tree on a car in front of the user). The results showed a user reaction to the proposed scenarios, recorded through changes in physiological signals. In particular, there is a slight increase in ECG signals and a noticeable change in SCL – Fig. 3.

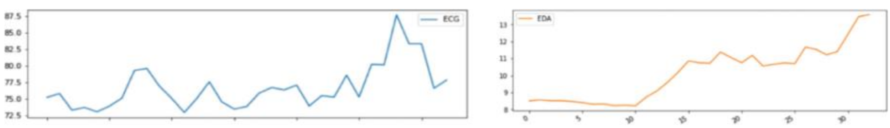

Fig. 3. ECG and EDA of the user, during the simulation

During the test the user experienced some nausea, probably due to motion sickness, which suggests that such experience should be run in a dynamic driving simulator, rather than on a VR headset.

AuthorProof

3 Discussion

The use of VR as a therapeutic tool has provided good clinical results for the treatment of anxiety disorders [20]. Our aim is to improve the effectiveness of this treatment by creating a phobic scenario that is dynamically calibrated to the level of tolerance of the patients, established via psychophysiological response (i.e., biofeedback signals).

This could be useful both for the user, to face his own fear independently, and for the psychologist, to know in real time the user's degree of fear and to intervene easily. We believe that building a phobic stimulus that changes based on the user's stress can allow the patient to feel safe, within the environment, which is essential for the success of the therapy [1]. Currently, the system for assessing the stress level of the user is very basic and might not be robust enough to detect subjective variability. We are currently implementing a machine learning algorithm that will allow detecting the stress level with a higher degree of accuracy. In order to train this algorithm, we will build a dataset of annotated stress data in driving conditions, with both healthy subjects and subjects affected by PTSD. Importantly, while the CyberTherapy platform has been built to treat PTSD due to road accidents, it can be easily adapted to other anxiety related scenario, thanks to the modular architecture of the system. Depending on the scenario (fixed or moving camera), the subject can experience the phobic stimuli either in VR or on a screen, respectively.

Acknowledgments. We thank the students Daniel D'Inca and Giovanni D'Italia for having participated in carrying out this work, as a support to the IT implementation.

References

1. Ventura, S., Baños, R.M., Botella, C., Mohamudally, N.: Virtual and augmented reality: new frontiers for clinical psychology. In: State of the Art Virtual Reality and Augmented Reality Knowhow, pp. 99–118. InTech (2018)
2. Steuer, J.: Defining virtual reality: dimensions determining telepresence. J. Commun. 42(4), 73–93 (1992)
3. Meehan, M., Insko, B., Whitton, M., Brooks, F.P.: Physiological measures of presence instressful virtual environments. In: Proceedings of SIGGRAPH 2002, San Antonio, TX, USA (2002)
4. Opriş, D., Pintea, S., García-Palacios, A., Botella, C., Szamosközi, Ş, David, D.: Virtual reality exposure therapy in anxiety disorders: a quantitative meta-analysis. Depression Anxiety 29(2), 85–93 (2012)
5. Botella, C., Fernández-Álvarez, J., Guillén, V., García-Palacios, A., Baños, R.: Recent progress in virtual reality exposure therapy for phobias: a systematic review. Curr. Psychiatry Rep. 19(7), 42 (2017)

6. Parsons, T.D., Rizzo, A.A.: Affective outcomes of virtual reality exposure therapy foranxiety and specific phobias: a meta-analysis. J. Behav. Ther. Exp. Psychiatry 39(3), 250– 261 (2008)
7. Anderson, P.L., Zimand, E., Hodges, L.F., Rothbaum, B.O.: Cognitive behavioral therapyfor public-speaking anxiety using virtual reality for exposure. Depression Anxiety 22(3), 156–158 (2005)
8. Hoffman, H.G., Garcia-Palacios, A., Carlin, A., Furness Iii, T.A., Botella-Arbona, C.: Interfaces that heal: coupling real and virtual objects to treat spider phobia. Int. J. Hum.Comput. Interact. 16(2), 283–300 (2003)
9. Minns, S., Levihn-Coon, A., Carl, E., Smits, J.A., Miller, W., Howard, D., Papini, S.,Quiroz, S., Lee-Furman, E., Telch, M., Carlbring, P.: Immersive 3D exposure-based treatment for spider fear: a randomized controlled trial. J. Anxiety Disord. 58, 1–7 (2018) [redacted]
10. Rizzo, A., Pair, J., Graap, K., Manson, B., McNerney, P.J., Wiederhold, B., Wiederhold, M.,Spira, J.: A virtual reality exposure therapy application for Iraq War military personnel with post traumatic stress disorder: from training to toy to treatment. NATO Secur. Through Sci. Ser. E Hum. Soc. Dyn. 6, 235 (2006)
11. Beck, J.G., Palyo, S.A., Winer, E.H., Schwagler, B.E., Ang, E.J.: Virtual reality exposuretherapy for PTSD symptoms after a road accident: an uncontrolled case series. Behav. Ther. 38(1), 39–48 (2007)
12. Rothbaum, B., Hodges, L., Ready, D., Graap, K., Alarcon, R.: Virtual reality exposuretherapy for Vietnam veterans with posttraumatic stress disorder. J. Clin. Psychiatry 62, 617– 622 (2001)
13. Wald, J.: Efficacy of virtual reality exposure therapy for driving phobia: a multiple baseline across-subjects design. Behav. Ther. 35, 621–635 (2004)
14. Clark, I.A., James, E.L., Iyadurai, L., Holmes, E.A.: Mental imagery in psychopathology: From the lab to the clinic. In: Watson, L.A., Berntsen, D. (eds.) Clinical Perspectives on Autobiographical Memory [Internet]. Cambridge University Press, Cambridge (2015)
15. Holmes, E.A., Mathews, A.: Mental imagery and emotion: a special relationship? Emotion 5 (4), 489–497 (2005)
16. Day, S., Holmes, E., Hackmann, A.: Occurrence of imagery and its link with early memoriesin agoraphobia. Memory 12(4), 416–427 (2004)
17. Kircanski, K., Mortazavi, A., Castriotta, N., et al.: Challenges to the traditional fear hierarchyin exposure therapy. J. Behav. Ther. Exp. Psychiatry 43, 745–751 (2012)
18. Braithwaite, J.J., Watson, D.G., Jones, R., Rowe, M.: A guide for analysing electrodermalactivity (EDA) & skin conductance responses (SCRs) for psychological experiments. Psychophysiology 49(1), 1017–1034 (2013)
19. Maples-Keller, J.L., Bunnell, B.E., Kim, S.J., Rothbaum, B.O.: The use of virtual realitytechnology in the treatment of anxiety and other psychiatric disorders. Harvard Rev. Psychiatry 25(3), 103 (2017)
20. Powers, M.B., Emmelkamp, P.M.: Virtual reality exposure therapy for anxiety disorders: ameta-analysis. J. Anxiety Disord. 22(3), 561–569